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# A SPECIAL CAMERA FOR PHOTOGRAPHING CYLINDRICAL SURFACES

BY

RAYMOND DAVIS, Photographic Technologist
*Bureau of Standards*

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# A SPECIAL CAMERA FOR PHOTOGRAPHING CYLINDRICAL SURFACES

By Raymond Davis

ABSTRACT

This paper describes a camera designed to photograph the entire outside surface of short lengths of pipe which have been subjected to soil corrosion tests.

The pipe is rotated by means of a belt which is driven by a pulley of the camera which also shifts the film. The film moves at a speed equal to the image velocity of the pipe. An automatic switch stops the camera after the complete surface of the pipe has been photographed. In this way a complete and clear picture of the pipe surface is obtained in a single photograph.

The general design is, of course, applicable to photographing other cylindrical objects.

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## I. INTRODUCTION

One of the sections of this bureau is engaged in a study of the corrosive action of soils on metal pipes of various compositions. In connection with this work there are buried in a number of selected places more than 7,000 pieces of pipe of several commercial sizes ranging from 1½ to 6 inches in diameter, all of which are 6 inches in length. At intervals of one or two years a sample of each is removed and brought to the bureau for study. To simplify comparisons, and for record purposes, it is desirable to have photographs of the corroded pipe. Photographs made with the usual camera would obviously show only a portion of the pipe, and that at a variable angle. It was decidedly more desirable to have one which would show the entire outside surface in one continuous picture. No such camera being obtainable commercially, and so far as we know none having ever been constructed, the design here described was undertaken.

## II. GENERAL DESIGN

Of the two methods by which the entire outside surface of a cylindrical object may be photographed in one piece, namely, revolving the camera around the cylinder or rotating the cylinder in front of the

camera, the second was chosen as the simpler for the purpose in hand. The second has several advantages over the first—it is much simpler to rotate the pipe than to revolve the entire outfit; also the source of illumination remains fixed.

With regard to choice of sensitive materials, film, because of its flexibility, was much preferred to glass plates.

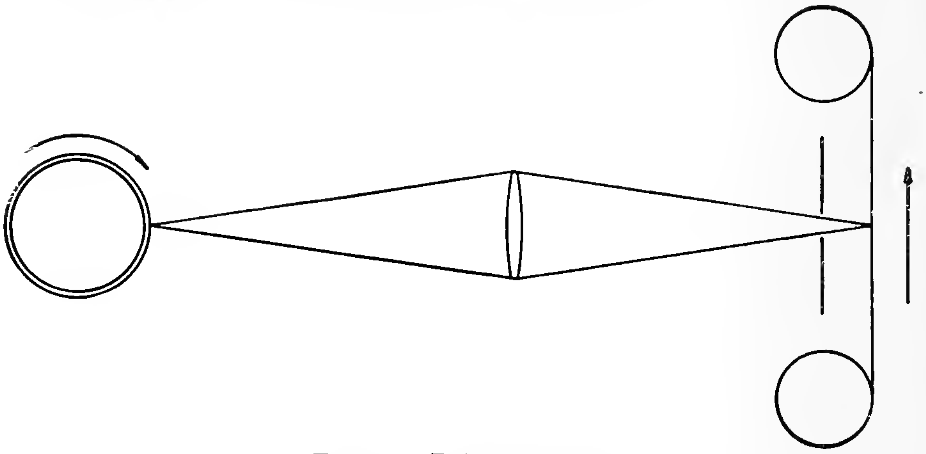

Fig. 1.—*Full-size image*

Speeds of pipe and film equal but opposite in direction

It was necessary to accommodate pipe specimens of different diameters, as stated above. It was, of course, also necessary to have the image of the pipe and the film move at equal velocities; hence, in rotating the pipe we are not concerned with velocities in terms of r. p. m., but of surface speeds. That is, to photograph the pipe full size (fig. 1), the film and the surface of the pipe should move at equal

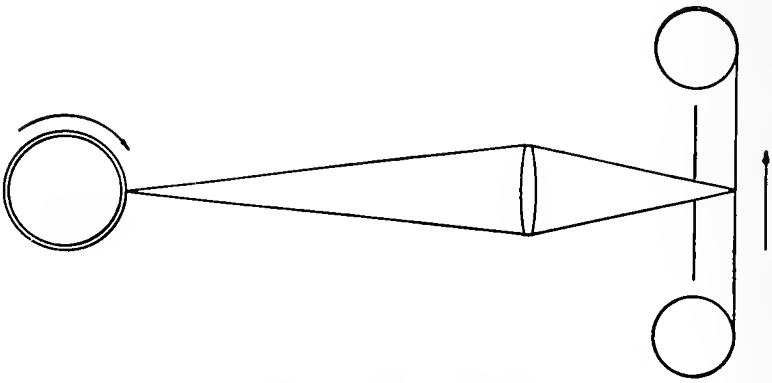

Fig. 2.—*Half-size image*

Pipe speed twice that of film and opposite in direction

speeds, but, of course, in opposite directions (because of inversion of the image); while for half size (fig. 2) the film should move just half as fast as the pipe surface. That is, the relative speeds of film and pipe must be in the ratio of image and object sizes.

With different sizes of pipe this requires the axis of rotation of the pipe to be shifted in accordance with the size as in Figure 3.

For providing synchronous motion of pipe and film, a belt drive (fig. 4) was chosen because of its simplicity in both design and construction.

In this, roller *R* moves the film *F* past the fixed focal plane shutter *A;* the surface of the pipe *P*, for photographing full size being moved at the same speed by means of the belt. To photograph, say, half

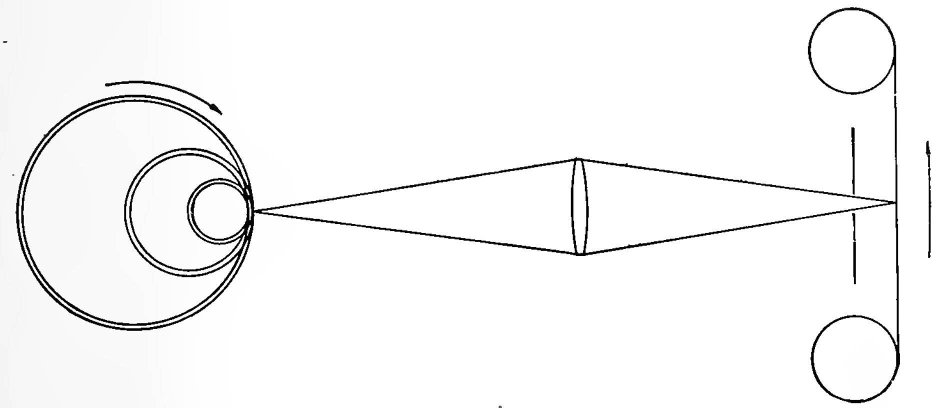

Fig. 3

size, all that is necessary, other than to change positions of pipe and lens to form half size image at the film, is to increase the size of the belt pulley attached to drum *R* to twice the diameter of the drum, thus causing the pipe to move at twice the speed of the film. By providing pulleys *P* of the same size as the pipe, any size pipe can then be photographed.

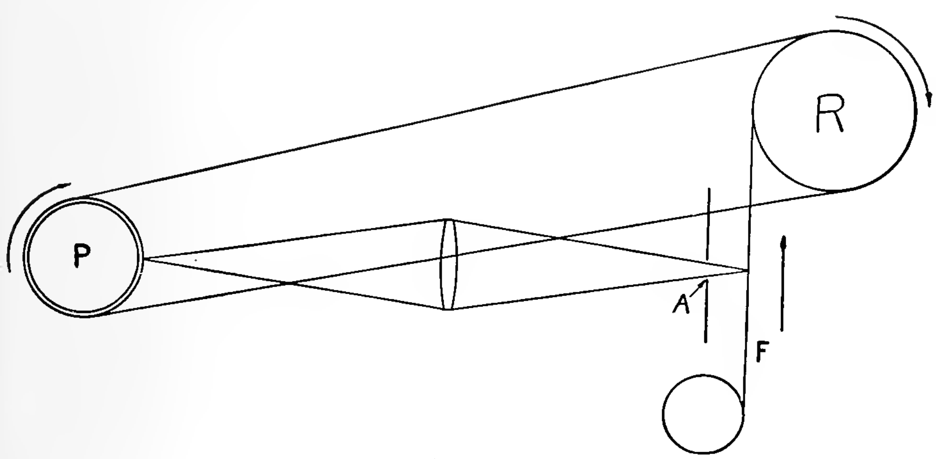


Fig. 4

To avoid any change in diameter of the take-up roller by accumulating thickness of film, the arrangement shown in Figure 5 was used.

Here the roller *R*, of rubber covered metal, serves to shift the film at the required speed, it being rewound on a second spool *T–2*. To insure adequate friction between roller *R* and film the small idle roller *W*, comparatively heavy, is carried by an arm pivoted at *X*.

The drive, which is electrical, is applied through the roller *R*, and from this to the pipe and film rewind.

For starting and stopping the exposure a shutter at the slit opens when the pipe and film start moving, and closes when these motions cease. The shutter is operated by the same current that drives the camera motor. Figure 6 shows a schematic plan of the shutter mechanism.

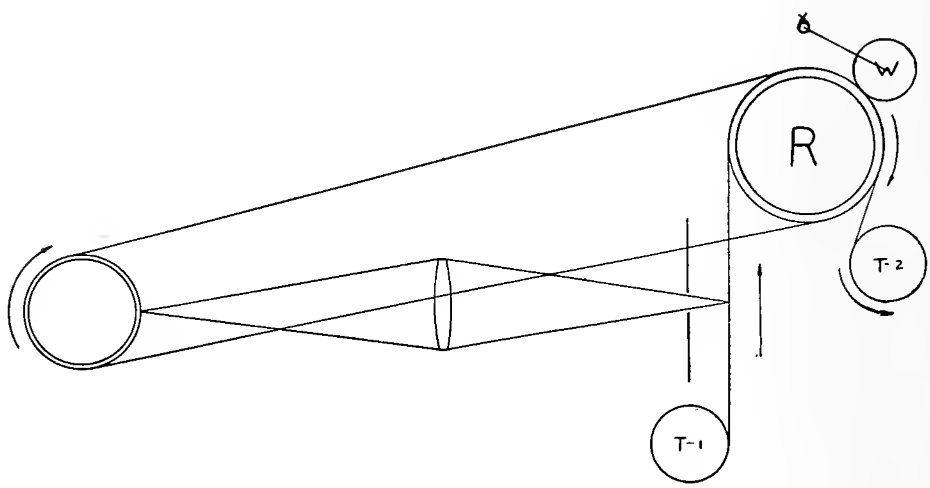


Fig. 5

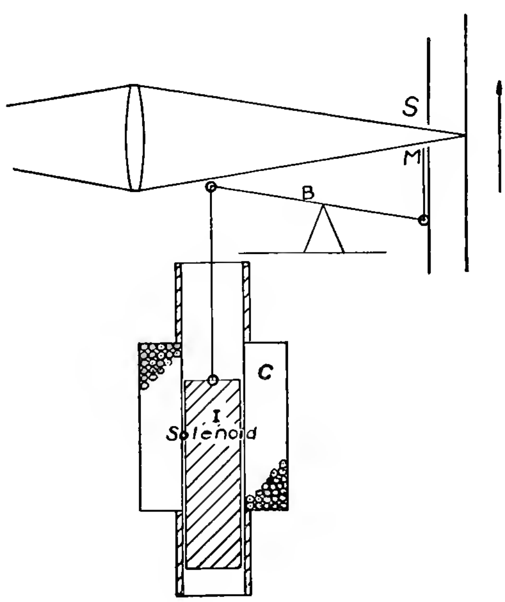


Fig. 6

The shutter blade *M* is carried on one end of a beam *B* pivoted in the center, while the other end carries a soft iron armature *I*. This armature is drawn upward (as shown) into solenoid *C*, when energized opening the shutter. When the current is broken the armature falls, closing the shutter.

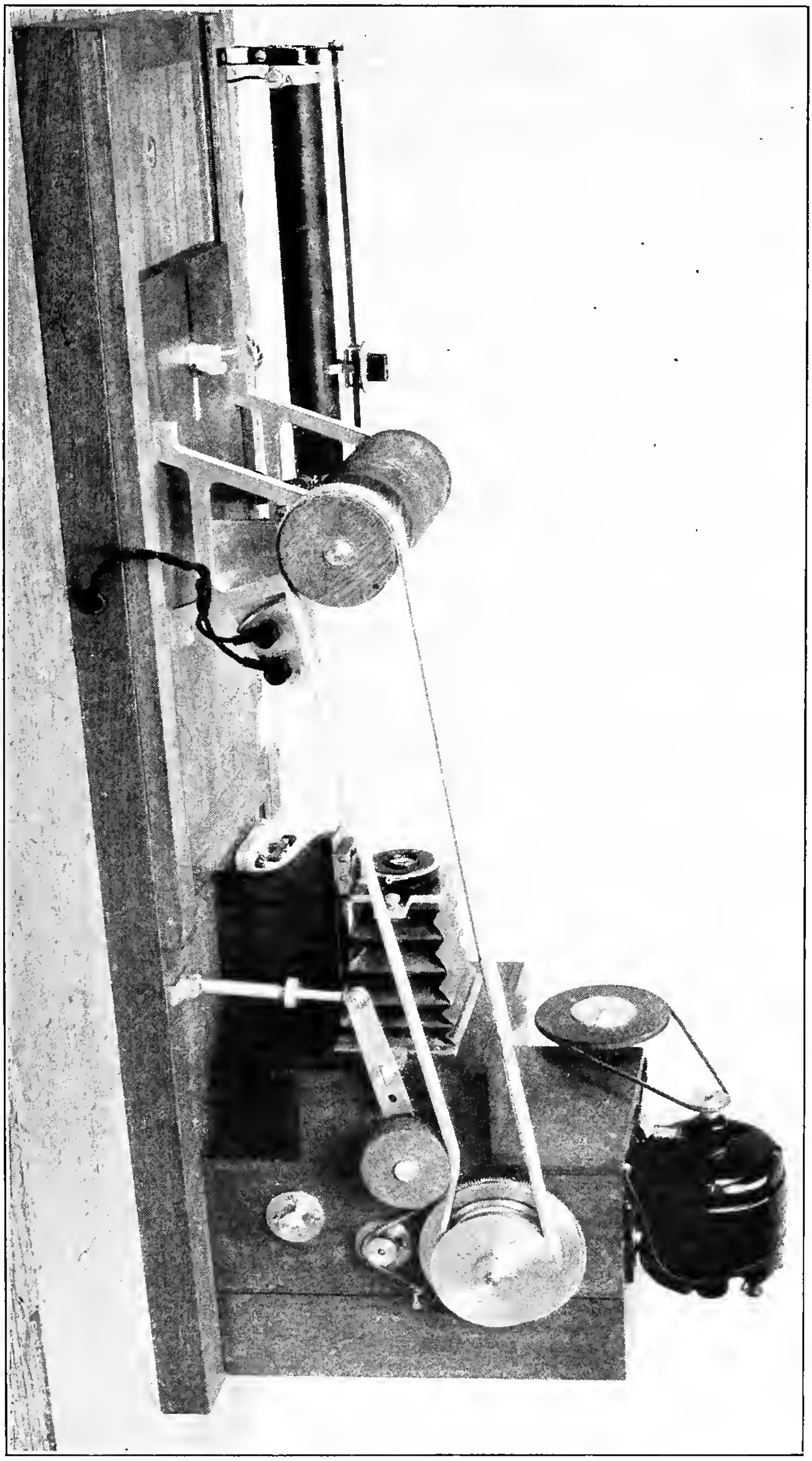

FIG. 7.—*View of the pipe camera showing the belt driven pipe in position for photographing*

## III. DESCRIPTION OF THE CAMERA

The camera box and bed (figs. 7 and 8) were made of baywood (often sold as mahogany), the metal parts of brass, iron, and steel. The motor, mounted on top of the camera, drives the film drum through a worm and gear. On the drum shaft outside is mounted a flanged pulley of the same diameter as the drum. The film leaves the bottom spool, passes through the slit gate, then over the drum, and is rewound on the second spool.

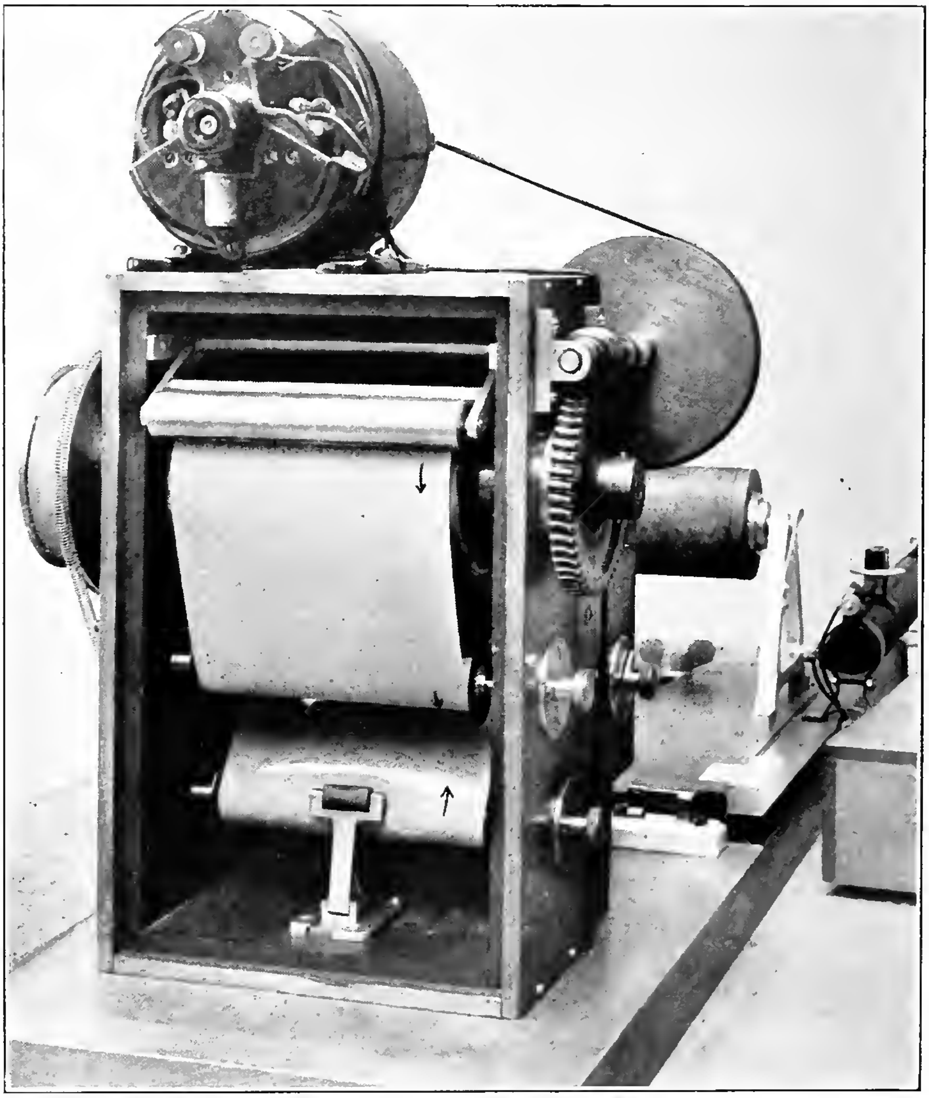

Fig. 8.—*Inside of the camera showing film-moving mechanism*

The drum is made of brass tubing covered with soft rubber. Resting on the film is a solid brass roller, the purpose of which is to press the film on the roller and thereby prevent slipping, as already noted. Pressing against the lower film spool is a small roller to prevent the film from unwinding more rapidly than it is taken up.

The rewind spool is driven through a coiled spring wire belt by the large grooved pulley attached outside to the drum shaft. The relative diameters of these two pulleys are so chosen that the film spool would, if there were no slippage of the spring belt, be driven more rapidly than is necessary to rewind the film. When rewinding the film, therefore, the belt crawls or slips over the pulleys, thus keeping the film moderately taut, and also taking care of the increase in effective diameter of the spool as the film is wound on it.

The choice of a suitable lens is governed by the same conditions as in ordinary photography. It is required to photograph a relatively narrow strip 6 inches long. In photographing an object full size the working focal length is double the equivalent focal length and

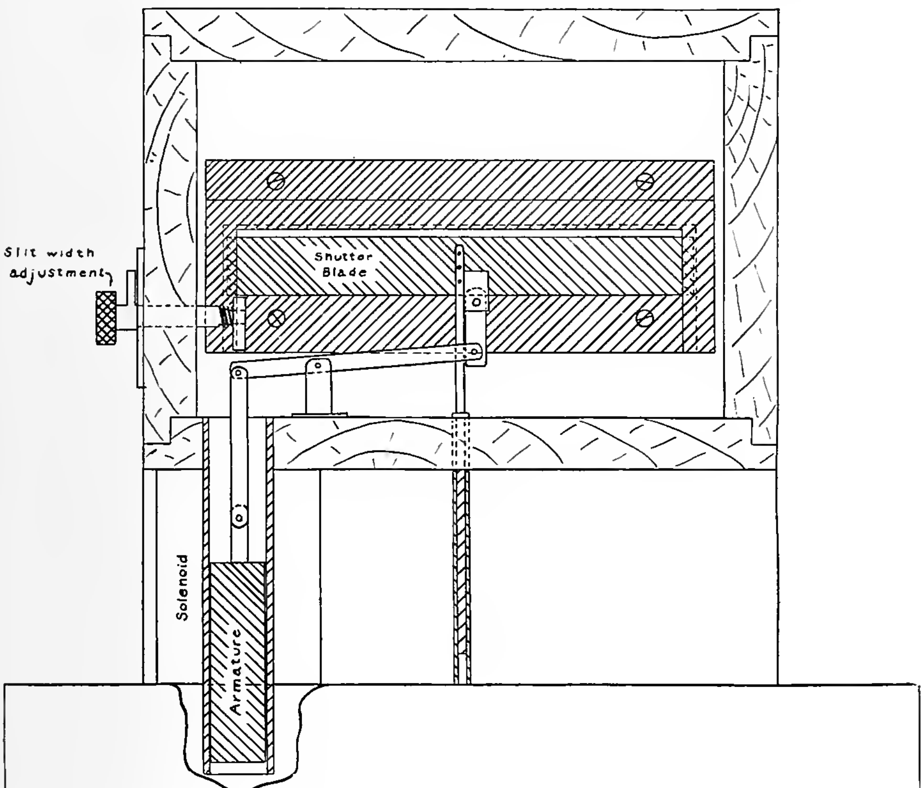


Fig. 9.—*Pipe camera shutter mechanism*

hence the "F" value becomes twice the value indicated on the lens mount; that is, a 9-inch equivalent focal length lens at an aperture of F 8 has, when photographing an object full size, a working focal length of 18 inches and thus an effective aperture of F 16. Under these conditions a lens will cover a plate twice the size for which it is designed, though it will have but one-fourth the speed. One may, therefore, choose a lens of shorter focal length than would ordinarily be required to cover a 6-inch plate, thereby gaining the advantage of a shorter camera bed which, in this case, is required to

support not only the camera, but also the object being photographed. The lens used is a Cook Anastigmat IIIa, 5-inch E.F. F.6.5., designed to cover a 3¼ by 4¼ plate.

The construction details of the focal plane shutter are shown in Figure 9. The armature is lifted upward when the solenoid is energized, opening the slit. The slit width is controlled by an adjustable stop fitted with a pointer and a scale. When the circuit is opened the armature falls, closing the slit.

The motor circuit (shown in fig. 10) is quite different from usual methods employed to control speed, and the same as that described in Scientific Paper No. 439. It is a so-called potentiometer control in which the voltage on the armature is varied from zero to maximum by a sliding contact on a rheostat which is across the line, the slider indicated by an arrowhead being movable the whole length of the resistance. This provides continuous adjustment from full rated speed to just turning over. It has the advantage of retaining the characteristics of a shunt motor at all speeds.

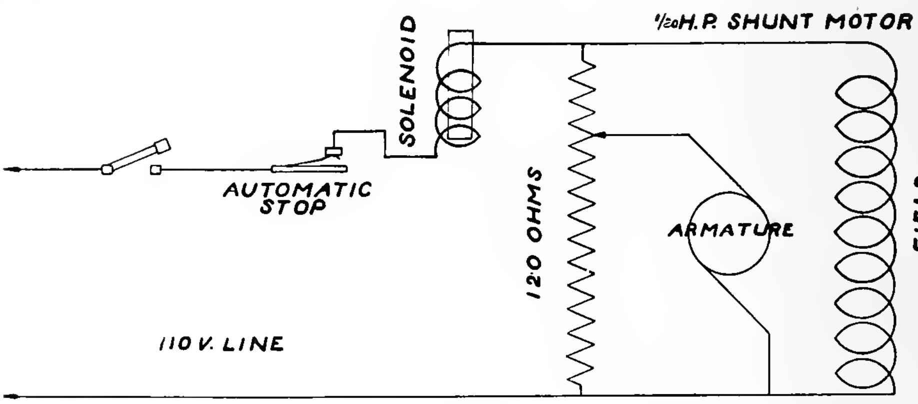


Fig. 10

The purpose of the slit is to restrict the angle of view of the object being photographed to a relatively narrow band parallel to the axis of the pipe. This is particularly necessary in order to maintain proportional velocities of the image and object. If the slit be too wide, regions of the pipe are included where the motion is out of parallel with the image plane; hence the image movement drops below that of the film, resulting in a blur. The maximum permissible slit width is practically proportional to the diameter of the pipe. A slit width of one-fourth inch gives excellent definition with 3-inch pipe.

The pipe specimens are mounted as shown in Figure 11—(*a*) is a pulley having the same diameter as the pipe, (*b*) a fixed plug, (*c*) a removable plug clamped by a threaded clamp ring (*d*). To mount the pipe the clamp ring and plug (*c*) are removed, the pipe slipped over the shaft onto (*b*), then (*c*) put on and clamped tight by (*d*). The lever (*e*) serves to trip a switch as explained below.

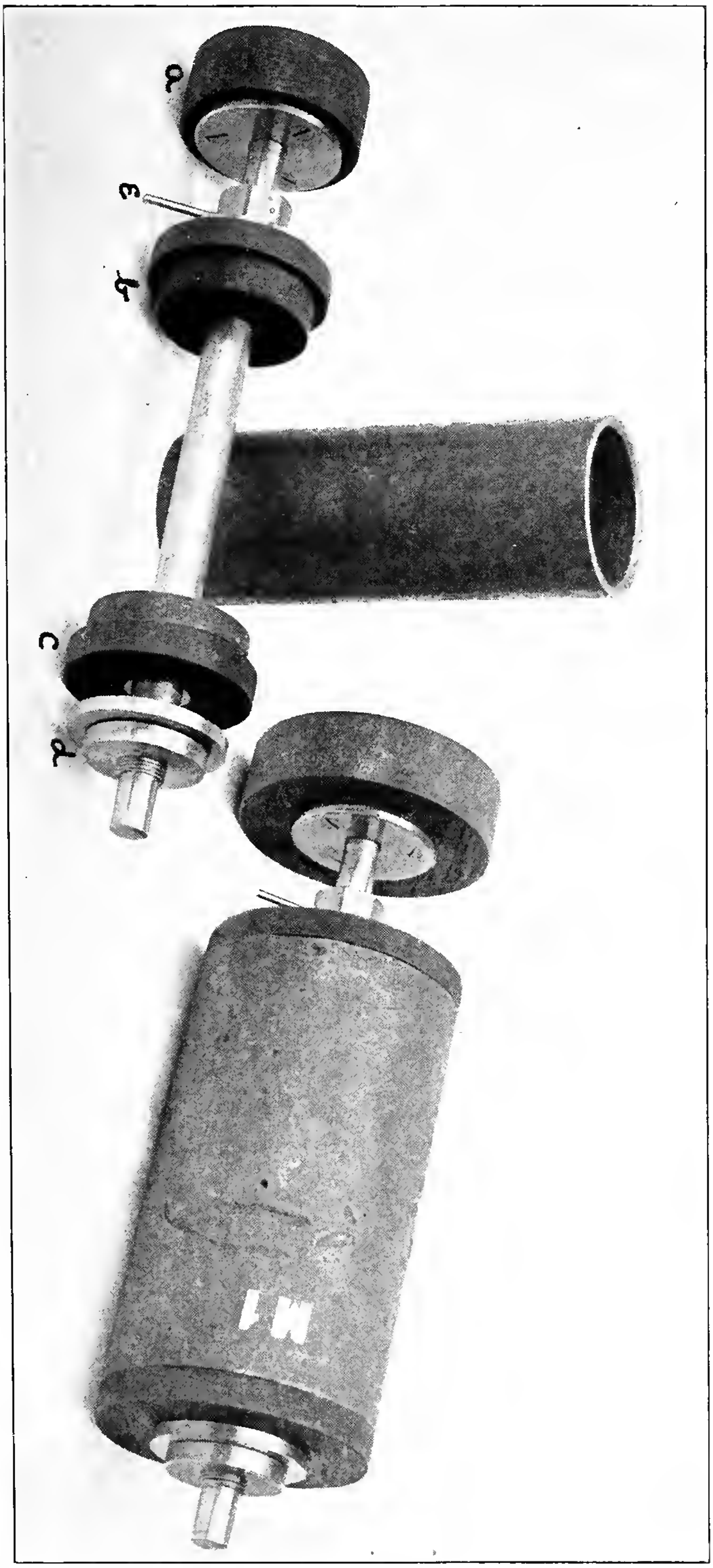


FIG. 11.—*Two views of pipe holder*

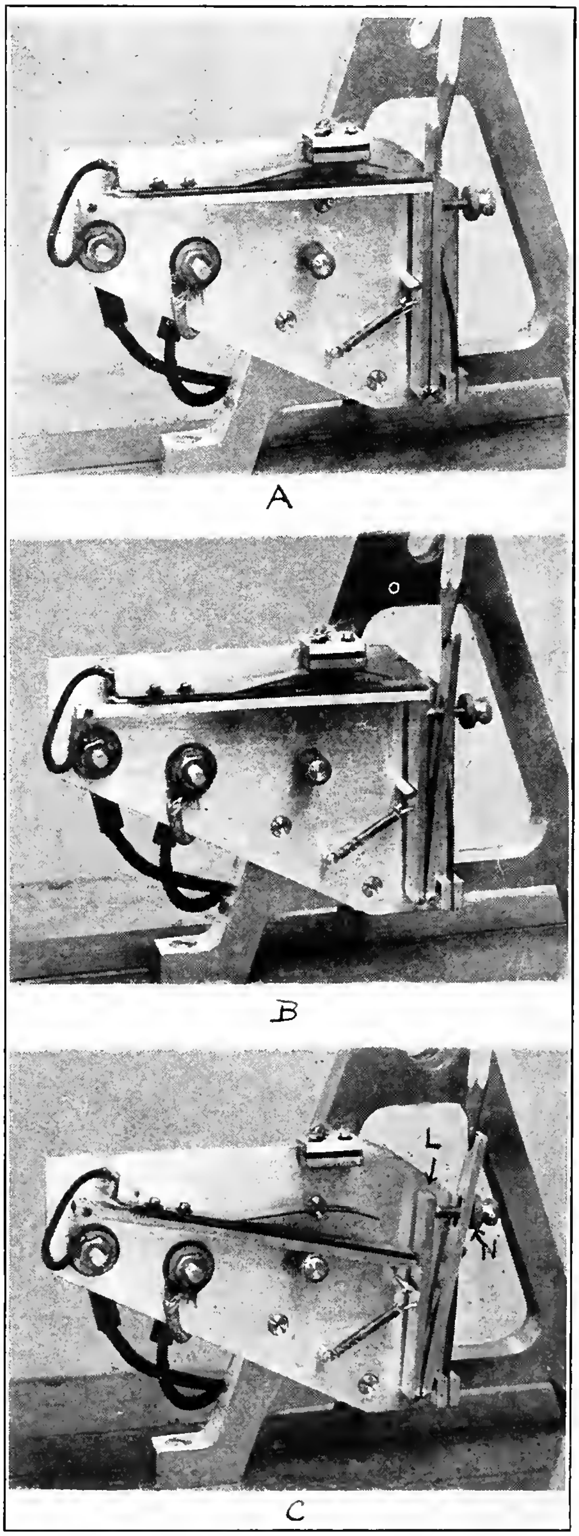


FIG. 12.—*Automatic switch for stopping camera after one revolution of the pipe*

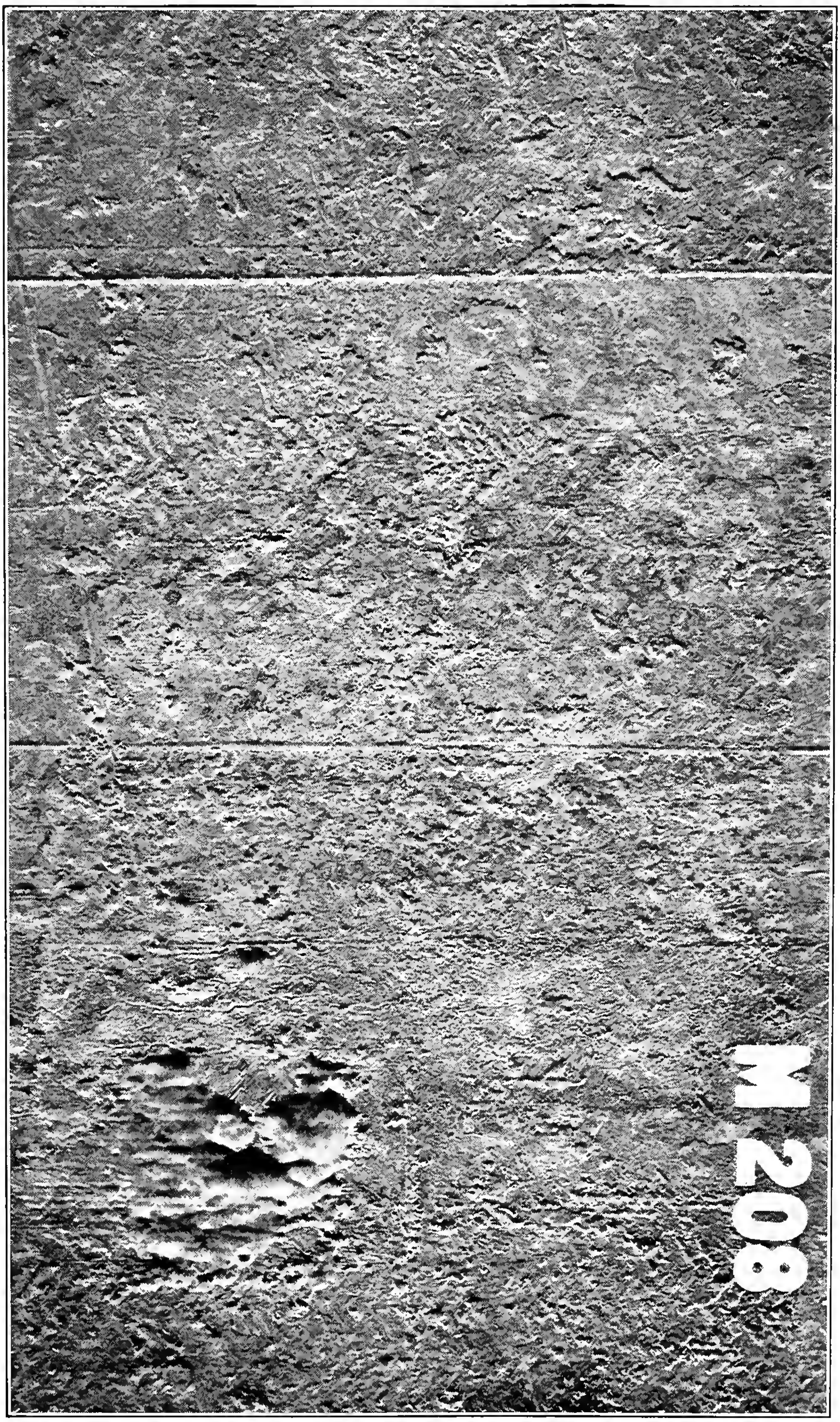


FIG. 13.—*Portion of a photograph of a 3-inch corroded pipe*

This photograph should be viewed with the illumination coming from the left-hand side, otherwise pits will appear as projections

As seen in Figure 7 the brackets which carry the pipe are mounted on an adjustable slide, which serves to set various sizes of pipe at the proper distance from the lens. A scale on this slide indicates the correct position for each pipe size. A separate driving belt is used with each size pipe, though a single belt with a take-up device might be used instead.

It is desirable to have the camera mechanism stop automatically when a photograph has been taken of the complete circumference plus a short overlap; that is, the motor should stop and the shutter close when the pipe has turned a little more than one revolution. This is accomplished by a suitable switch, shown in Figure 12, which is operated by rod *E* of Figure 11. In Figure 12, a lead pencil is shown in the place of the rod. *A* is the position just before starting; *B* shows the position of the finger and switch lever after the pipe has made one revolution counterclockwise; and *C* shows the switch lever pressing against the stop-nut *N*, which in turn pulls the latch *L* so that the switch arm falls, opening the circuit.

Figure 13 gives a reduction of a photograph of a 3-inch pipe. For the sake of detail the full length is not reproduced.

A mercury vapor lamp was chosen for a light source, with the lamp tube placed parallel to the pipe and a short distance in front so that the rays fall on the section photographed at an angle of approximately 40°. About 2½ feet of pipe surface or film per minute is the usual rate of speed when photographing full size.

Washington, May 22, 1925.